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20 April 1994
JEG:9010:94:083

Advanced Research Projects Agency
Contracts Management Office
Virginia Square Plaza
3701 North Fairfax Drive, Rm. 927
Arlington, VA 22203-1714

Attention: Mr. Donald Sharkus

Subject: Contract No. MDA972-91-C-0032

Dear Mr. Sharkus:

Raytheon Company, Research Division, is pleased to submit herewith the Ninth Quarterly Progress Report for the subject contract. This report covers the period December 1993 to February 1994.

If you should have any questions, please contact the undersigned at (617) 860-3134.

Sincerely yours,

John E. Greene, Jr.
Assistant Contracts Manager

cc: Advanced Research Projects Agency
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RAYTHEON COMPANY
Research Division
131 Spring Street
Lexington, MA 02173

RF VACUUM MICROELECTRONICS

9th Quarterly Progress Report
December 1993 to February 1994

RAY/RD/S-4982

19 April 1994

Contract No. MDA972-91-C-0032

Sponsored by

Advanced Research Project Agency
Defense Sciences Office

1.0 EXECUTIVE SUMMARY

Third iteration chip design fabrication and testing was started. New mounting alumina was received and tested and it works as desired. The third mounting vacuum flange was received and tested. The "Cold Match" of fixtured devices was obtained with external tuners. Simulations of tip capacitance and fringing capacitance were started.

2.0 MILESTONES STATUS

	Completion Date Original	Act/Est
1. Utilize features of new evaporator to improve moly tips	4/94	4/94
2. Capacitance Issue	9/93	4/94
3. Lower work function	3/94	5/94
4. High frequency design/fab #3	1/94	3/94
5. Source pull measurements	3/94	4/94
6. Load pull measurements	5/94	5/94

3.0 TECHNICAL PROGRESS

The third iteration chips, alumina and anode design were "cold tested" in the test fixture. The alumina have good performance up to 2.5 GHz and do not radiate. The measurement at 1 GHz into a 50 ohm resistors gives a return loss of less than -40 db (1%). The time domain measurement shows a smooth peak indicated no internal mismatches. The anode structure was redesigned to try to maintain 50 ohms along the line as far as possible. The calculation of the impedance of an oddly shaped conductor over a ground plane is not trivial. The design allowed for alumina sleeves over the anode line for impedance control. However, the best results were obtained with no sleeves. The time domain shows a smooth peak with insertion loss of less the 10% with no internal mismatches.

A chip was mounted and then the input and output tuned for best match at 1 GHz. The tuners were commercial models (Microlab/ FXR models SF-11F, 0.3 to 1.7 GHz). The matches and insertion loss are shown in Figure 1a through 1c. The input match (Figure 1a) was 16 dB, the output match (Figure 1b) 24 dB, and the isolation (Figure 1c) was 19 dB. The 3 dB bandwidth is about 10 MHz (1%). This relatively poor isolation will limit device performance.

The cathodes are routinely measured in pulse mode. In our measurement set-up, the RF can also be observed directly on a high speed digitizing scope. However, the pulser and the RF source are not phase locked so only the RF envelope and not the RF wave can be observed. By using two synthesized sources and a pulse generator, the whole system can be phase locked. An HP 8656A (0.1 to 990 MHz) synthesizer is phased locked through the common 10 MHz clocks to an HP 8665B (0.1 to 6 GHz) synthesizer. The first unit is run at 0.1 MHz and the second at 1 GHz. The output of the first is used to trigger an HP 8112A pulse generator which is used to set the pulse width and duty cycle of the pulse to the device bias. The second unit provides the main RF signal.

Simulations have been started to look at the capacitance of the FEA cathodes. The tip capacitance as a function of tip height is being evaluated with a two-dimensional Poisson solver in R-Z geometry. The code is being modified to handle the dielectric layer. The capacitance of the gate metal to emitter metal is being evaluated using the Hewlett Packard High Frequency Simulator. This product is a full three dimensional solver. The problem we are finding is that the launch of the incoming signal from the side introduces some reactance. For the low reactance structures (0.15 pf), this reactance is on the same order of magnitude as the structure itself. We are looking at ways to de-embed this launch.

The third mask design was completed and masks ordered and received. The first set of wafers have completed processing and are being tested. The peeling problem discussed in the last report

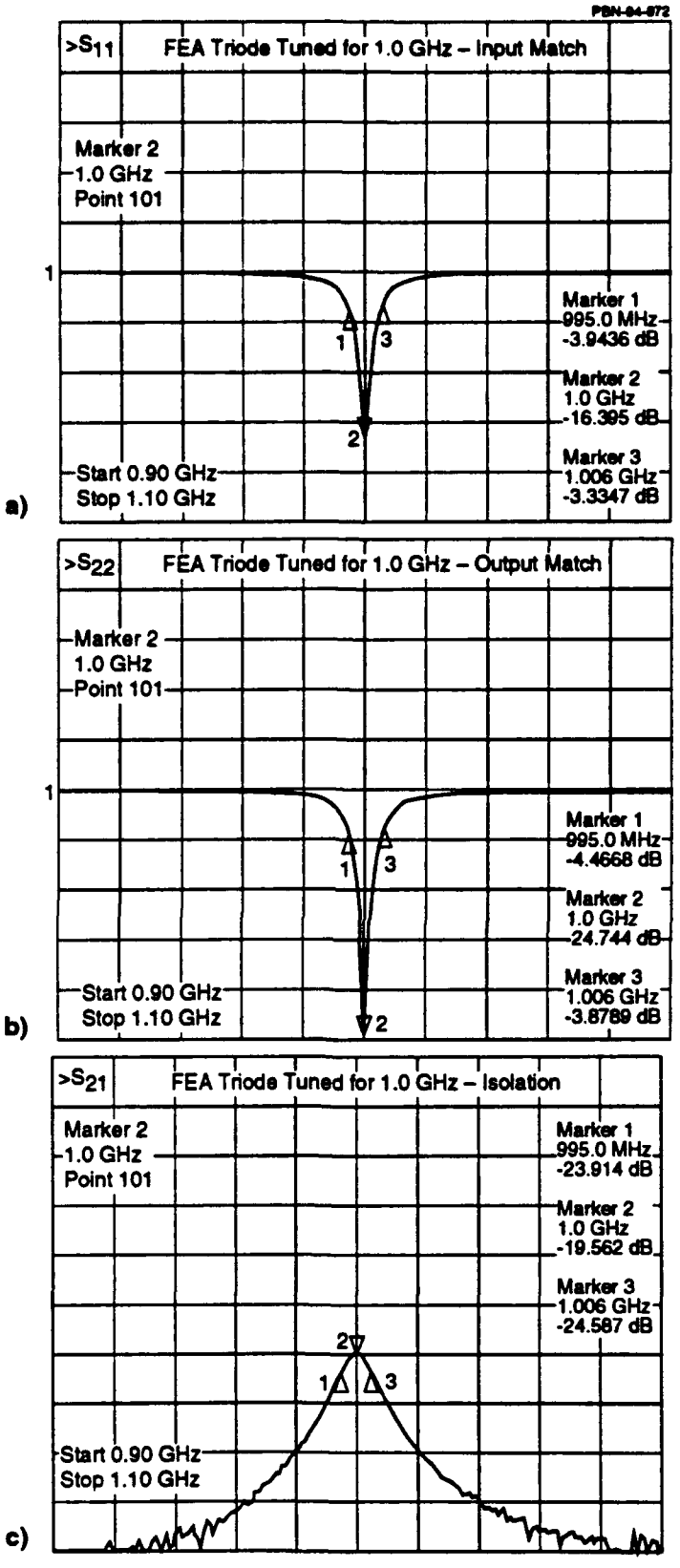

Figure 1. (a)Input Match, (b) Output Match, and (c) Isolation.

was found to be the gate metalization coming off when the excess tip metal was removed. The exact cause of this problem is not known, however, the yield is good enough to provide chips for testing.

4.0 FISCAL STATUS

CONTRACT NO: MDA972-91-C-0032
CONTR. TITLE: RF VACUUM MICROELECTRONICS-OPTION
CONTRACTOR: RAYTHEON CO., RESEARCH DIV.

DATE PREPARED: 15-Mar-94
REPORT PERIOD: 01/31/94-02/27/94

FUNDS AND MANHOUR EXPENDITURE REPORT

CONTRACT VALUE:	$467,710
CURRENT FUNDING (cell):	$467,710
NEG. FEE RATE:	0.0%
% FUNDING SPENT & COMMITTED:	63.2%

	CONTRACT VALUE	REPORTING MO. EXPEN-DITURES	CUMULATIVE EXPEND. TO DATE	% $ VALUE	COST TO COMPLETE ESTIMATE	LATEST COST ESTIMATE	PREVIOUS COST ESTIMATE
A	B	C	D	E	F	G	H
TOTAL PRIME LABOR HOURS	4,794	459	2,754		1,632	4,386	4,794
TOTAL PRIME LABOR	$133,120	$12,831	$78,223		$49,818	$128,041	$133,120
LABOR OVERHEAD	$228,935	$22,392	$140,485		$86,938	$227,423	$228,935
TOTAL LABOR & OVERHEAD	$362,055	$35,223	$218,708		$136,756	$355,464	$362,055
MATERIALS	$29,000	$3,883	$25,484		$3,117	$28,601	$29,000
ODC	$0	$2,763	$3,156		$6,400	$9,556	$0
IWR	$0	$0	$246		$1,254	$1,500	$0
PRODUCT COST	$391,055	$41,869	$247,594		$147,527	$395,121	$391,055
G & A	$62,031	$6,381	$37,483		$22,098	$59,581	$62,031
COM	$14,624	$1,247	$7,336		$5,099	$12,435	$14,624
TOTAL COST LEVEL	$467,710	$49,497	$292,413		$174,724	$467,137	$467,710
FEE	$0	$0	$0		$0	$0	$0
TOTAL CONTRACT PRICE	$467,710	$49,497	$292,413	62.52%	$174,724	$467,137	$467,710
OUTSTANDING COMMIT.		$3,036	$3,036				
TOTAL COMMIT & EXPEND.	$467,710	$52,533	$295,449	63.17%		$467,137	$467,710

EXPENDITURES THIS QUARTER:	$126,822
TOTAL EXPENDITURES TO DATE:	$292,413
PROJECTED EXPENDITURES:	
03/94 - 05/94:	$169,287
06/94 - 08/94:	$6,010
TOTAL EXPENDITURES TO DATE:	$292,413
PROJECTED ADDITIONAL EXPENDITURES:	$175,297
1) IS CURRENT FUNDING SUFFICIENT (Y/N):	YES
2) WHAT IS FY93's FUNDING REQUIREMENT?:	$467,710
3) IS ALL DATA CROSS REFERENCED?:	YES

5.0 PROBLEM AREAS

The devices must have at least 1 micro-amp per tip performance to be evaluated in terms of power, gain, and noise. Most of the devices fail before achieving those current level. We have no "cold" indicator of what will make a good device. Therefore, we have to "hot" test many devices to find one that can be evaluated. We hope that the addition of a small series resistance in the emitter line will help alleviate the problem.

6.0 VISITS AND TECHNICAL PRESENTATIONS

None